

## CLAIMS

### WHAT IS CLAIMED IS:

- 1                   1.     An optoelectronic device comprising:  
2                   a multilayer semiconductor structure including an InP  
3 substrate and an active region, the active region comprising at least a  
4 hole quantum well layer of a semiconductor containing antimony and at  
5 least one electron quantum well layer adjacent to the hole quantum well  
6 layer which comprises a semiconductor containing nitrogen to provide a  
7 type II quantum well structure.
- 1                   2.     The device of Claim 1 wherein the semiconductor  
2 containing antimony is GaAsSb or InGaAsSb and the semiconductor  
3 containing nitrogen is InAsN or InGaAsN.
- 1                   3.     The device of Claim 2 wherein there is an electron  
2 quantum well layer on each side of the hole quantum well layer and there  
3 is a barrier layer adjacent to each electron quantum well layer on each  
4 side of the hole quantum well layer to provide a conduction band profile  
5 for the active region having a W-shaped configuration.
- 1                   4.     The device of Claim 3 wherein the electron quantum  
2 well layers are in compressive strain and the hole quantum well layer is in  
3 compressive strain.
- 1                   5.     The device of Claim 3 wherein the electron quantum  
2 well layers are in compressive strain and the hole quantum well layer is in  
3 tensile strain.

1                   6.     The device of Claim 3 wherein the thickness of each  
2     electron quantum well layer and hole quantum well layer is between  
3     approximately 10 and 50 angstroms.

1                   7.     The device of Claim 3 wherein the barrier layers  
2     comprise GaInP.

1                   8.     The device of Claim 1 wherein the electron quantum  
2     well layers and hole quantum well layer form a first quantum well stage,  
3     and wherein the active region comprises a plurality of quantum well  
4     stages adjacent to each other each having electron quantum well layers  
5     surrounding a hole quantum well layer.

1                   9.     The device of Claim 8 including a barrier layer between  
2     each quantum well stage to provide a conduction band profile having a W-  
3     shaped configuration.

1                   10.    The device of claim 9 wherein the barrier layer  
2     between each quantum well stage comprises GaInP.

1                   11.    The device of Claim 1 including means for providing  
2     optical feedback to form an edge-emitting laser.

1                   12.    The device of Claim 1 including means for providing  
2     optical feedback to form a vertical cavity surface emitting laser.

1                   13.    The device of Claim 1 wherein the active region  
2     generates light having a wavelength greater than approximately 2  $\mu\text{m}$ .

1                   14.    The device of Claim 1 wherein the active region  
2     generates light having a wavelength of approximately 3  $\mu\text{m}$ .

1                   15. The device of Claim 1 wherein the nitrogen content of  
2 the electron quantum well is 10% or less.

1                   16. An optoelectronic device comprising:  
2 a multilayer semiconductor structure including an InP  
3 substrate and an active region, the active region comprising at least a  
4 hole quantum well layer of GaAsSb or InGaAsSb and an electron quantum  
5 well layer of InAsN or InGaAsN on each side of the hole quantum well  
6 layer to provide a type II quantum well structure.

1                   17. The device of Claim 16 wherein the electron quantum  
2 well layers are in compressive strain and the hole quantum well layer is in  
3 compressive strain.

1                   18. The device of Claim 16 wherein the thickness of each  
2 electron quantum well layer and hole quantum well layer is between  
3 approximately 10 and 50 angstroms.

1                   19. The device of Claim 16 including a barrier layer  
2 adjacent to each electron quantum well layer to form a conduction band  
3 profile having a W-shaped configuration.

1                   20. The device of Claim 19 wherein the barrier layer  
2 comprises GaInP.

1                   21. The device of Claim 16 wherein the electron quantum  
2 well layers and hole quantum well layer form a first quantum well stage,  
3 and wherein the active region comprises a plurality of quantum well  
4 stages adjacent to each other.

1                   22. The device of Claim 21 including a barrier layer of  
2                   GaInP between each quantum well stage to form a conduction band  
3                   profile having a W-shaped configuration.

1                   23. The device of Claim 16 wherein the percentage of Ga  
2                   content of the electron quantum well layers is no more than 30%.

1                   24. The device of Claim 16 including means for providing  
2                   optical feedback to form an edge-emitting laser.

1                   25. The device of Claim 16 including means for providing  
2                   optical feedback to form a vertical cavity surface emitting laser.

1                   26. The device of Claim 16 wherein the nitrogen content  
2                   of the electron quantum wells is 10% or less.

1                   27. An optoelectronic device comprising:  
2                   a multilayer semiconductor structure including an InP  
3                   substrate and an active region, the active region comprising at least a  
4                   hole quantum well layer of GaAsSb and a electron quantum well layer of  
5                   InAsN on each side of the hole quantum well layer to provide a type II  
6                   quantum well structure wherein the electron quantum well layers are in  
7                   compressive strain and the hole quantum well layer is in compressive  
8                   strain.

1                   28. The device of Claim 27 wherein the electron quantum  
2                   well layers are lattice matched to InP.

1                   29. The device of Claim 27 wherein the thickness of each  
2                   electron quantum well layer and hole quantum well layer is between  
3                   approximately 10 and 50 angstroms.

1                   30. The device of Claim 27 including a barrier layer  
2 adjacent to each electron quantum well layer to form a conduction band  
3 profile having a W-shaped configuration.

1                   31. The device of Claim 30 wherein the barrier layers  
2 comprise GaInP.

1                   32. The device of Claim 27 wherein the electron quantum  
2 well layers and hole quantum well layer form a first quantum well stage,  
3 and wherein the active region comprises a plurality of quantum well  
4 stages adjacent to each other.

1                   33. The device of Claim 27 including a transitional layer of  
2 GaInP between each quantum well stage.

1                   34. The device of Claim 27 including means for providing  
2 optical feedback to form an edge-emitting laser.

1                   35. The device of Claim 27 including means for providing  
2 optical feedback to form a vertical cavity surface emitting laser.

1                   36. The device of Claim 27 wherein the active region  
2 generates light having a wavelength greater than approximately 2  $\mu\text{m}$ .

1                   37. The device of Claim 27 wherein the active region  
2 generates light having a wavelength of approximately 3  $\mu\text{m}$ .

1                   38. The device of Claim 27 wherein the nitrogen content  
2 of the electron quantum wells is 10% or less.

1                   39. A semiconductor laser comprising:

2                   (a) a multilayer semiconductor structure including an InP  
3 substrate and an active region, the active region comprising at least a  
4 hole quantum well layer of a semiconductor containing antimony and at  
5 least one electron quantum well layer adjacent to the hole quantum well  
6 layer which comprises a semiconductor containing nitrogen to provide a  
7 type II quantum well structure; and

8                   (b) means for providing optical feedback to provide lasing  
9 action in the active region.

1                   40. The laser of Claim 39 wherein there is an electron  
2 quantum well layer on each side of the hole quantum well layer and there  
3 is a barrier layer adjacent to each electron quantum well layer on each  
4 side of the hole quantum well layer to provide a conduction band profile  
5 for the active region having a W-shaped configuration.

1                   41. The laser of Claim 40 wherein the semiconductor  
2 containing antimony is GaAsSb or InGaAsSb and the semiconductor  
3 containing nitrogen is InAsN or InGaAsN.

1                   42. The laser of Claim 40 wherein the electron quantum  
2 well layers are in compressive strain and the hole quantum well layer is in  
3 compressive strain.

1                   43. The laser of Claim 40 wherein the electron quantum  
2 well layers are in compressive strain and the hole quantum well layer is in  
3 tensile strain.

1                   44. The laser of Claim 40 wherein the thickness of each  
2 electron quantum well layer and hole quantum well layer is between  
3 approximately 10 and 50 angstroms.

1                   45. The laser of Claim 40 wherein the barrier layer  
2 comprises GaInP.

1                   46. The laser of Claim 40 wherein the electron quantum  
2 well layers and hole quantum well layer form a first quantum well stage,  
3 and wherein the active region comprises a plurality of quantum well  
4 stages adjacent to each other each having electron quantum well layers  
5 surrounding a hole quantum well layer.

1                   47. The laser of Claim 46 including a barrier layer of GaInP  
2 between each quantum well stage.

1                   48. The laser of Claim 39 wherein the means for providing  
2 optical feedback forms an edge-emitting laser.

1                   49. The laser of Claim 39 wherein the means for providing  
2 optical feedback forms a vertical cavity surface emitting laser.

1                   50. The laser of Claim 39 wherein the active region  
2 generates light having a wavelength greater than approximately 2  $\mu\text{m}$ .

1                   51. The laser of Claim 39 wherein the active region  
2 generates light having a wavelength of approximately 3  $\mu\text{m}$ .

1                   52. The laser of Claim 39 wherein the nitrogen content of  
2 the electron quantum wells is 10% or less.